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Intra-day realized volatility for European and USA stock indices

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ABSTRACT

The paper constructs measures of intra-day realized volatility for 17 European and USA stock indices. We utilize a model-free de-noising method by assembling the realized volatility in sampling frequency selected according to the volatility signature plot, which minimizes the microstructure effects. Having verified the stylized facts of realized volatility, the dynamic behavior of correlation between realized volatilities is investigated. The correlation among realized volatilities is positive and extremely high, although for some periods, it decreases dramatically. The correlation of volatilities within USA (or Europe) is much higher than the correlation of volatilities across USA and Europe. Moreover, we provide evidence that the inter-day adjusted realized volatility reduces significantly the underestimation of the true variability.

1. Introduction

Empirical finance literature provides various methods of refining intra-day prices in order to measure the daily volatility. The objective of the paper is to fill the gap in the literature between theoretical aspects and empirical applications of constructing realized volatility. In particular, we extend the literature by examining

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a long-length data set for 17 European and USA stock indices. We consider a range of European and USA indices to be able to extend previous studies, which mainly consider data from few markets[1]. The proposed method of constructing realized volatility offers useful findings for practitioners.

Following recent papers on realized volatility forecasting and market microstructure noise (e.g., Andersen, Bollerslev, & Meddahi, 2011), the paper advocates choosing a model-free[2] de-noising approach for the construction of intra-day realized volatility measures. This method has the advantage of being accurate-to-estimate and, at the same time, straightforward to apply (simple in terms of numerical computations). The high-frequency log-returns are constructed according to the previous tick method, in order to get volatility measures that do not converge in probability to zero. In addition, the realized volatility measures are assembled in sampling frequency selected according to the volatility signature plot by minimizing the noise accumulation due to market frictions.

The paper provides an extension of the earlier empirical investigations reported in Andersen, Bollerslev, Diebold, and Ebens (2001), Andersen, Bollerslev, Diebold, and Labys (2001), Andersen, Bollerslev, Frederiksen, and Nielsen (2010), Andersen et al. (2011), Hansen and Lunde (2005), Jungbacker and Koopman (2006), and Thomakos and Wang (2003). These papers provide evidence on the stylized facts of realized volatilities using traditional approaches under several assumptions. We extend these studies by explicitly accounting for the stylized facts of realized volatilities in a simple form; this is highly important for financial decision-makers who deal with high-frequency data sets.

In particular, we investigate the distributional properties of realized stock return volatilities of the major European and USA markets and verify the stylized facts noted in financial literature. The results from 17 European and USA markets support empirically the notion that inter-day adjusted realized standard deviation is highly leptokurtic and skewed to the right, while the daily realized volatility is approximately log-normally distributed. The standardized log-returns with the realized standard deviation have a 94% lower standard deviation and 69% lower kurtosis than the raw log-returns.

Additionally, the paper provides evidence that the correlation between realized volatilities is not constant across time. Although the correlation between realized volatilities is positive and high, for some periods, it decreases dramatically. The correlation within USA (or European) volatilities is much higher than the correlation across USA and European volatilities. Pushing the analysis one step further, we confirm that the inter-day adjusted realized volatility reduces significantly the underestimation of the true variability (of the integrated variance).

In the section follows, the theoretical framework of *integrated variance* and the concept of the *realized volatility* are illustrated. Section 3 describes easy-to-implement adjustment procedures for the construction of realized volatility estimators, the linear interpolation and the previous tick methods for constructing the sequence of the calendar time sampling prices, and the volatility signature plot to identify the bias induced by microstructure frictions. Section 4 applies the proposed method to construct the realized volatility for 17 European and USA stock indices. Section 5 investigates the variance reduction of integrated volatility due to the inter-day adjustment. Section 6 investigates the time-varying correlation among the realized volatilities. Section 7 provides information for the distribution of *inter-day adjusted* realized standard deviations, whereas Section 8 concludes and provides insights for future research.

2. Ultra-high-frequency realized volatility

The time interval $[a, b]$ is partitioned in τ equidistance points (sub-intervals) in time $j = 1, 2, \ldots, \tau$. At each point in time t_j, for $t_j \ni [a, b]$, the asset price is observed. The $\left\{P_{t_j}\right\}_{j=1}^{\tau}$ process is observed at sampling frequency $m = (b - a)/(\tau - 1)$, for length of each sub-interval $m = t_j - t_{j-1}$.[3] The $y_{t_j} = \log P_{t_j} - \log P_{t_{j-1}}$ denotes

[1] This is important as the current debate on the 2008 financial crisis gives emphasis to the *domino effect* of the major stock markets.

[2] By the term *model-free*, we note a de-noising method that does not assume a predefined model configuration for microstructure noise.

[3] We denote the sampling frequency m, which lowers as the number of samples increases. On the contrary, the notion of *ultra-high frequency* defines the mean of high number of equidistance points in time τ. In the remaining of the manuscript, when the points in time, i.e., the size of the sample, increase, we will note that the sampling frequency increases.

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